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Auckland et al.

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(54) MANDREL-WOUND MAGNETIC ANTENNA AND METHOD OF MAKING SAME

(71) Applicants: **David Auckland**, College Park, MD (US); **Chris Daniel**, Westminster, MD (US)

(72) Inventors: **David Auckland**, College Park, MD (US); **Chris Daniel**, Westminster, MD (US)

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(51) **Int. Cl.**
H01Q 1/36 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/364*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/2225; H01Q 7/00; H01Q 1/38; H01Q 1/364
USPC 343/787, 866, 867, 742; 235/492; 29/600, 850
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,728,284	B1 *	4/2004	Birx et al.	372/82
8,558,752	B2 *	10/2013	Amadeo et al.	343/867
2011/0204147	A1 *	8/2011	Amadeo et al.	235/492
2011/0205140	A1 *	8/2011	Amadeo et al.	343/866

* cited by examiner

Primary Examiner — Lam T Mai

(57) **ABSTRACT**

An antenna includes an electrical excitation component and a core component. The electrical excitation component has and input, an output and a conducting component. The conducting component is disposed between the input and the output and can conduct current from the input to the output. The core component has a concentrically wound magnetic film having a substrate and a magnetic material layer. The core component can have a magnetic current loop induced therein. The electrical excitation component is arranged such that concentric magnetic fields associated with current conducted through the electrical excitation component are additionally associated with a magnetic current loop within the core component.

20 Claims, 19 Drawing Sheets

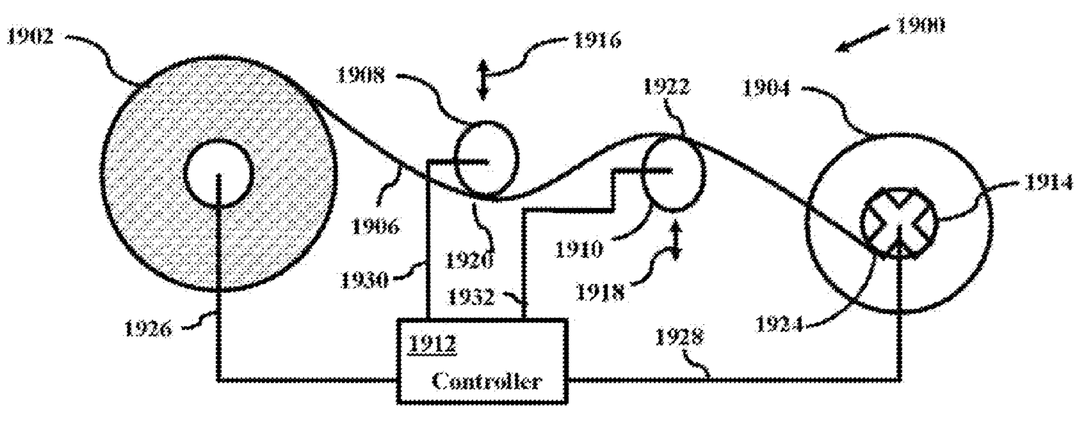
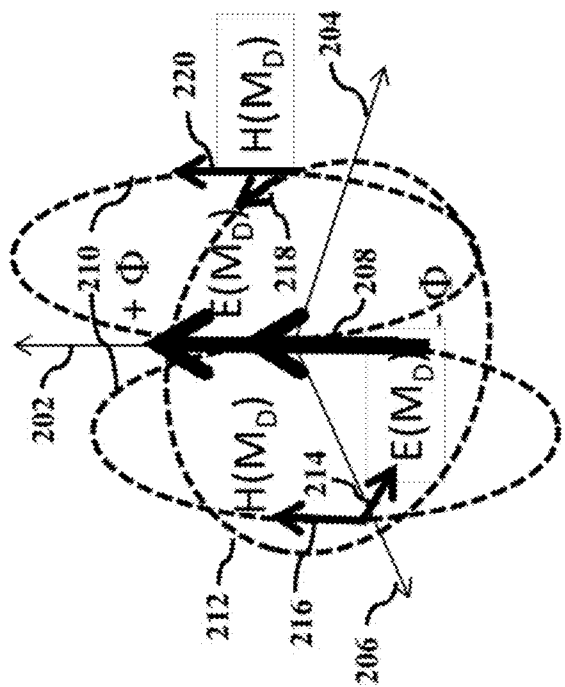
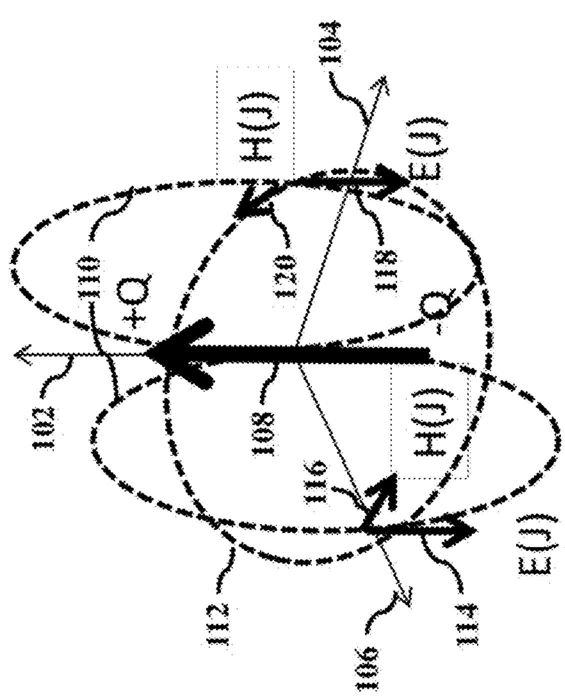


FIG. 2



202
204
206
208
210
212
214
216
218
220
+ Φ
- Φ
$E(M_D)$
$H(M_D)$
$E(M_D)$
$H(M_D)$

FIG. 1



102
104
106
108
110
112
114
116
118
120
+Q
-Q
H(J)
E(J)
H(J)
E(J)

FIG. 4

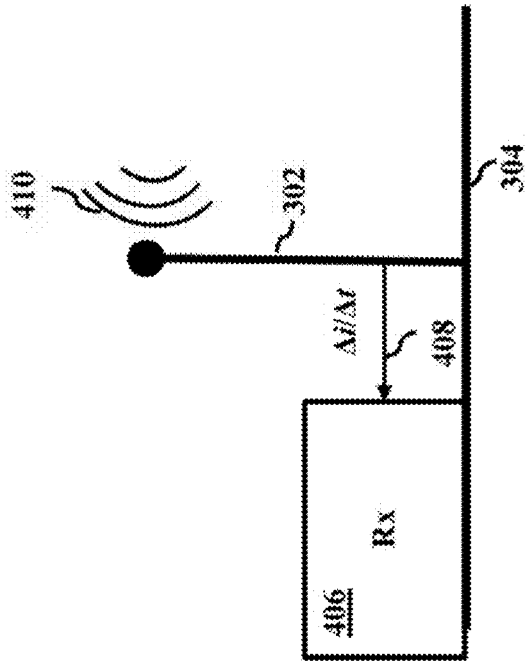
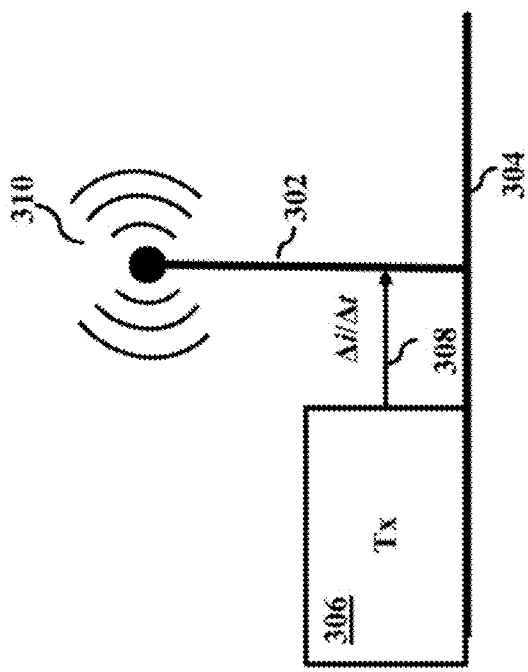

410
302
304
$\Delta i/\Delta t$
408
Rx
406

FIG. 3


310
302
304
$\Delta i/\Delta t$
308
Tx
306

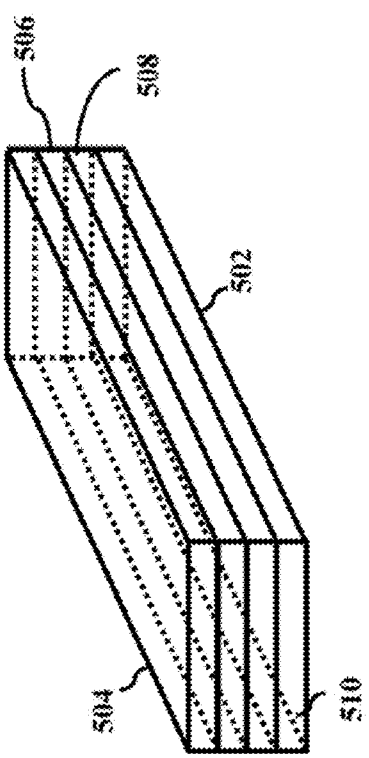


FIG. 5A

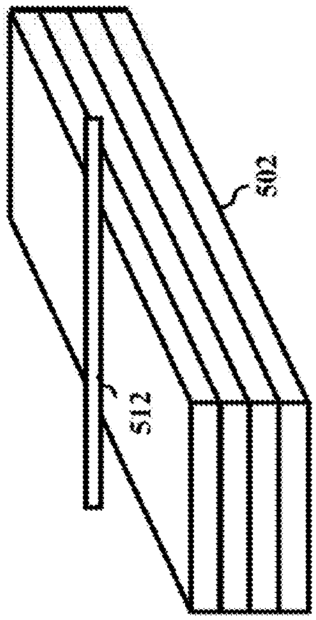


FIG. 5B

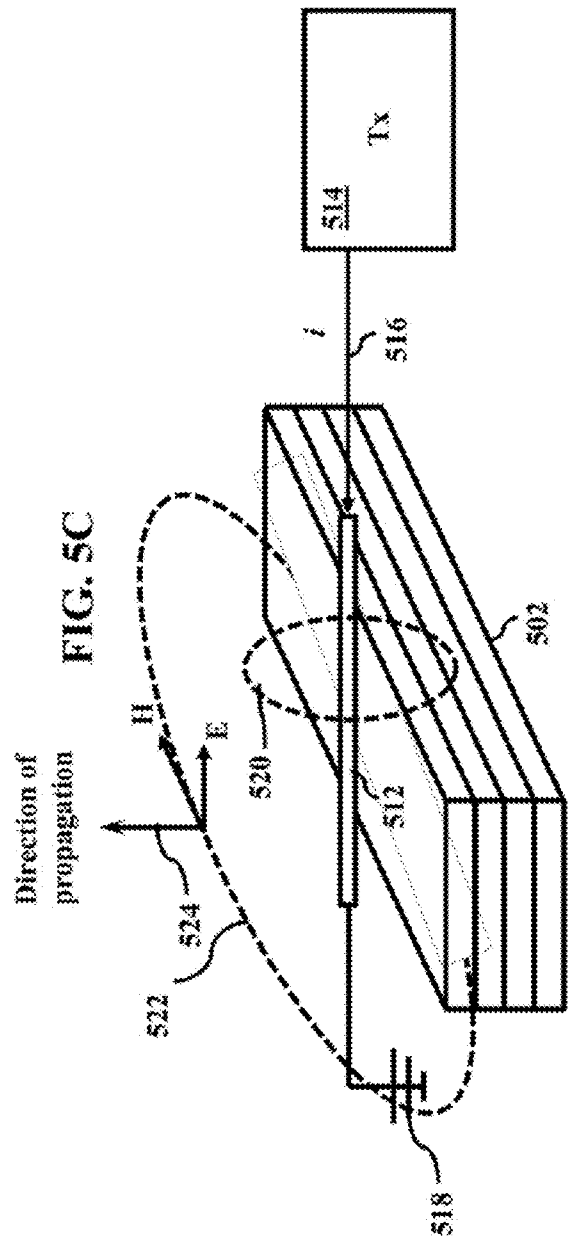


FIG. 5C

FIG. 7

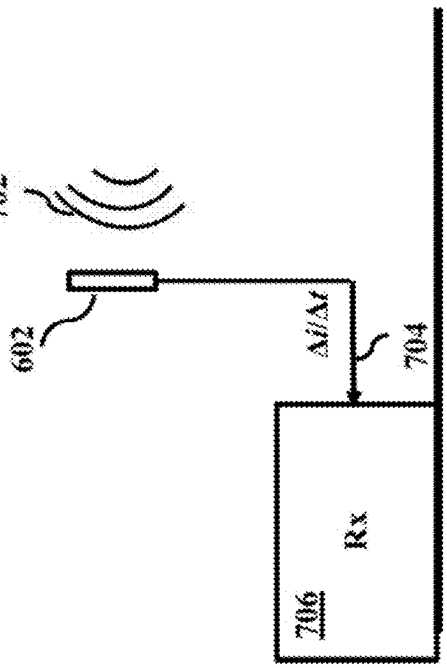


FIG. 6

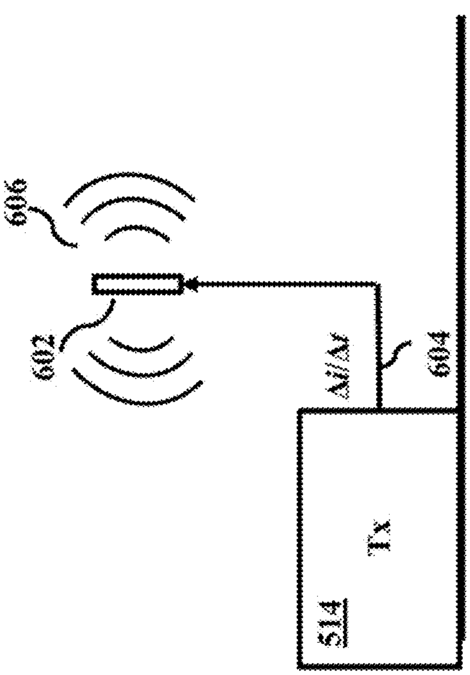


FIG. 8

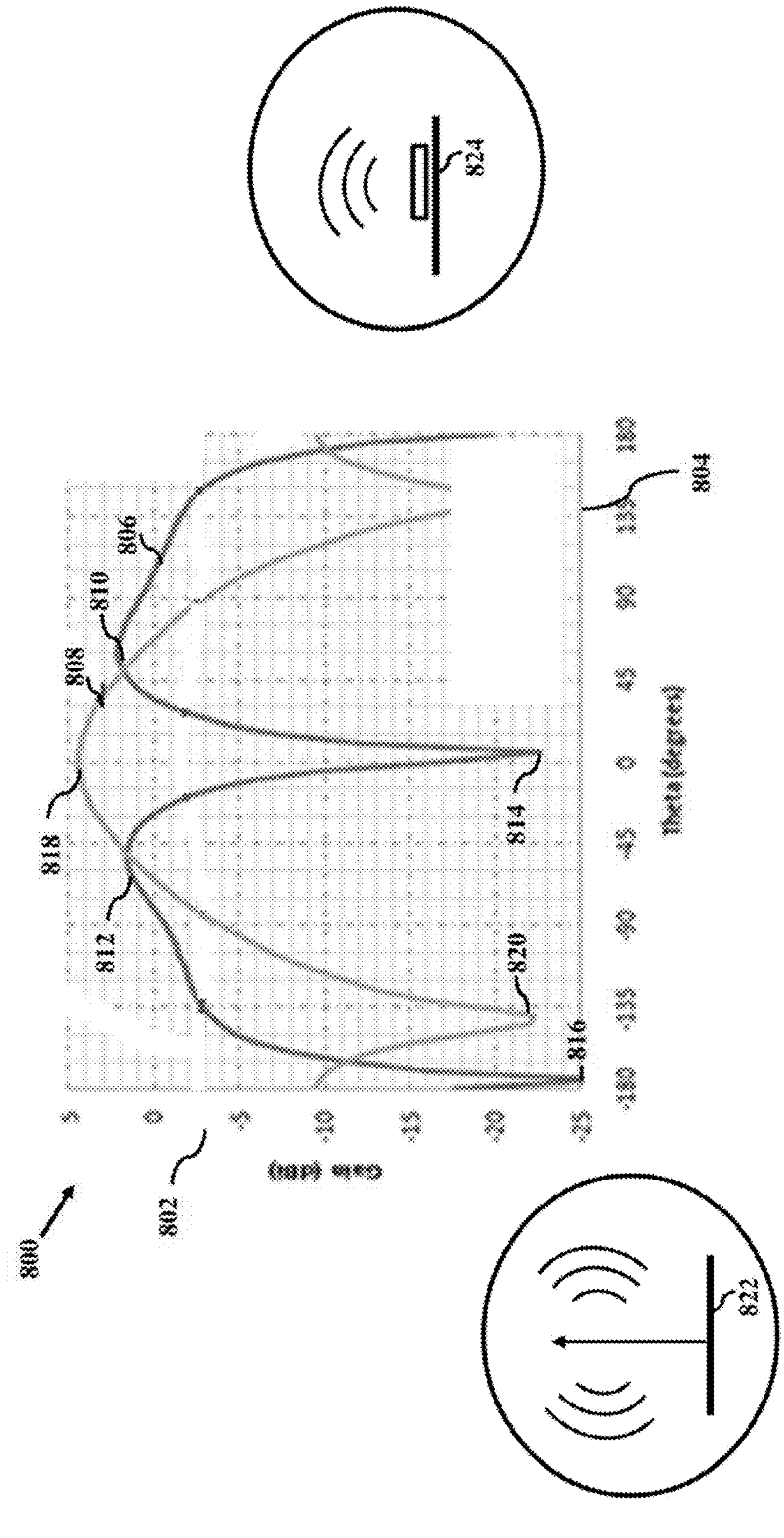
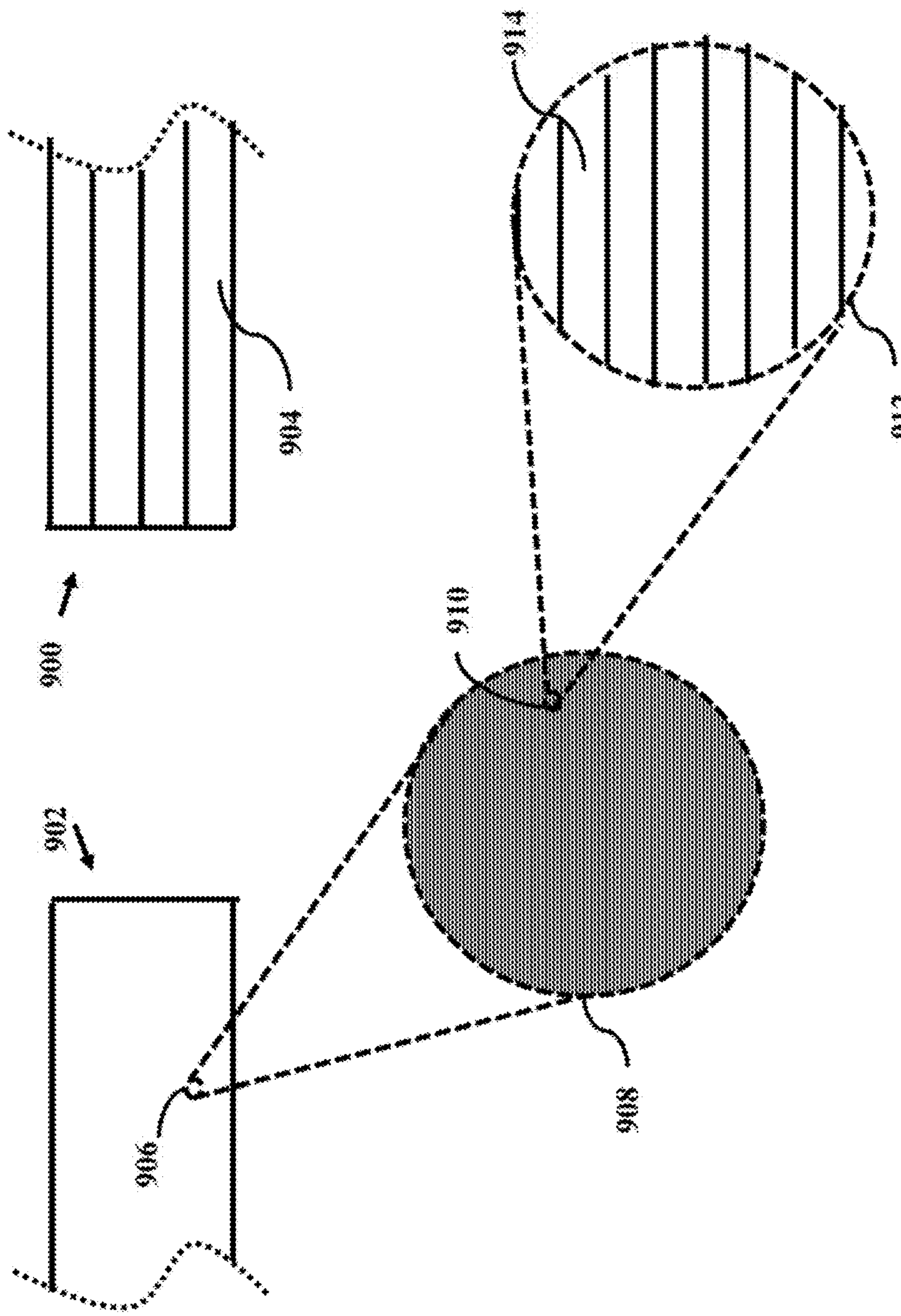

800
802
804
806
808
810
812
814
816
818
820
822
824
Gain (dB)
Theta (degrees)
5
0
-5
-10
-15
-20
-25
-180
-135
-90
-45
0
45
90
135
180

FIG. 9



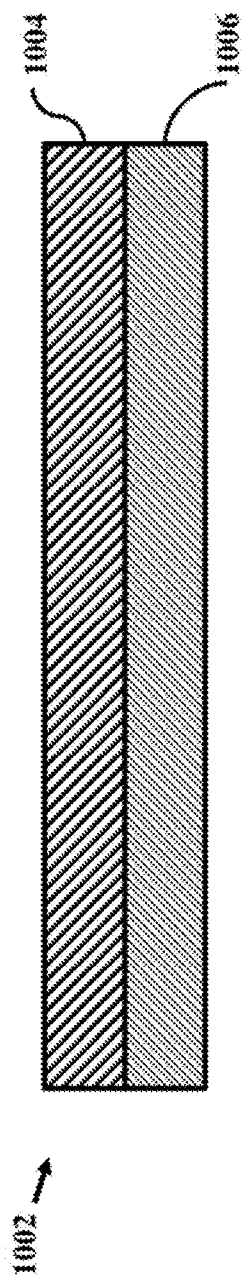


FIG. 10

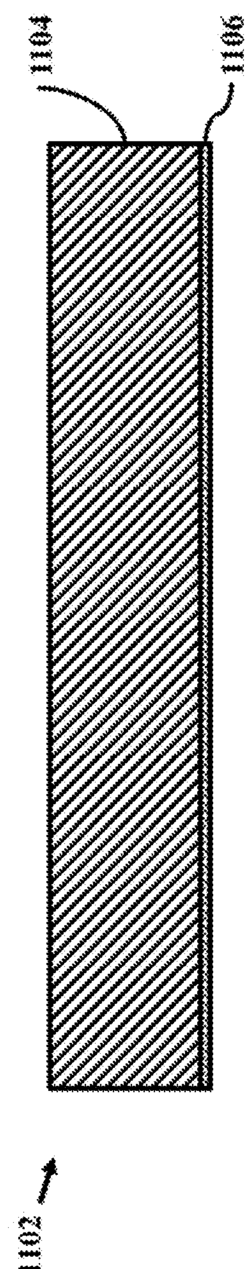


FIG. 11

FIG. 12

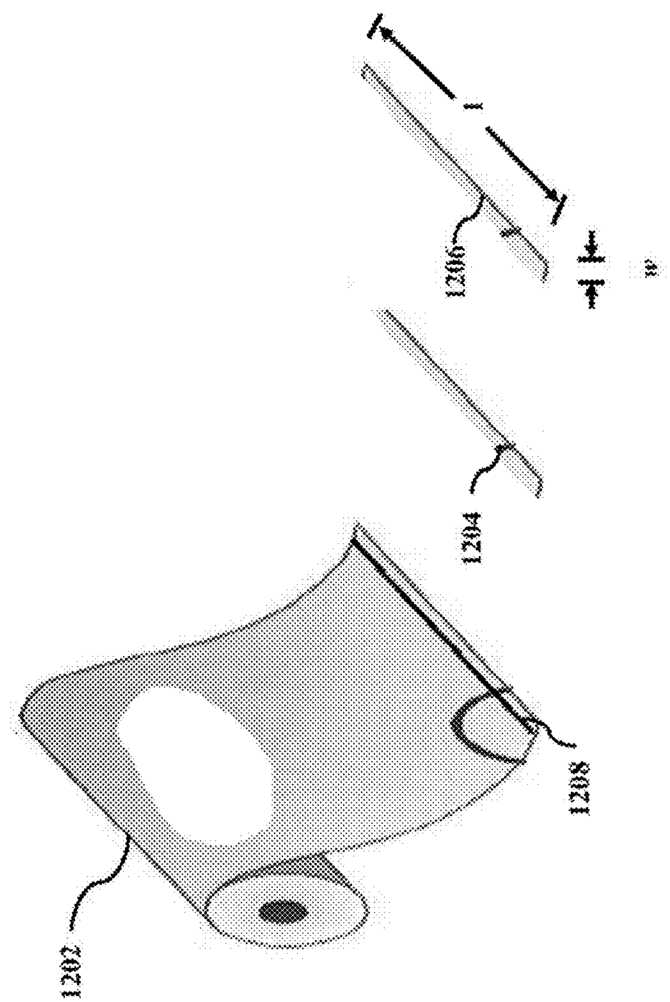


FIG. 13

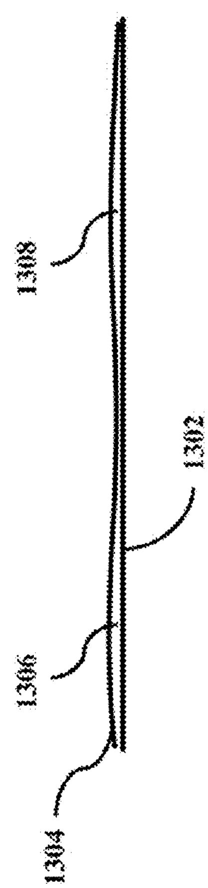


FIG. 14

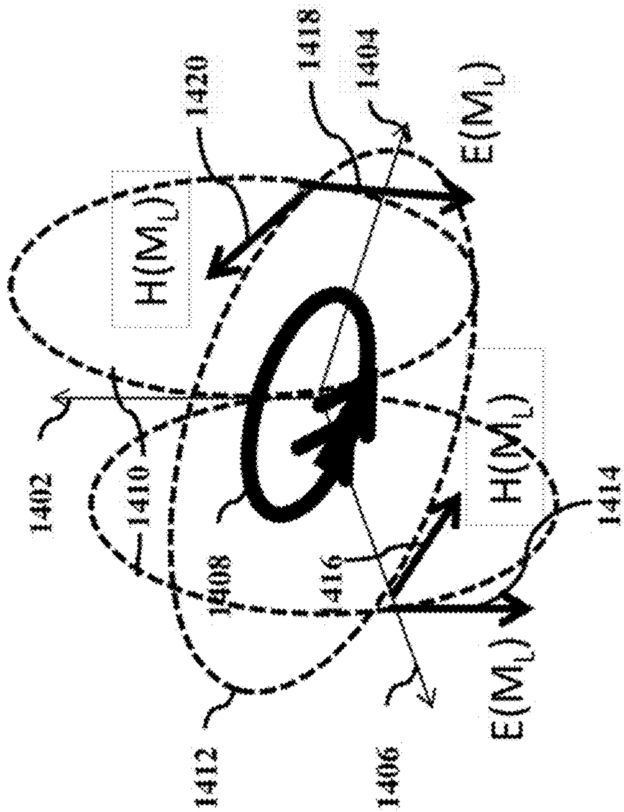


FIG. 16

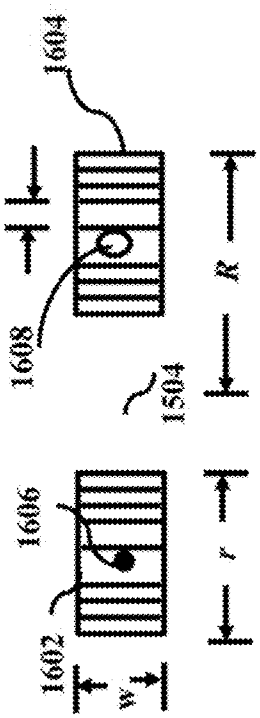


FIG. 15

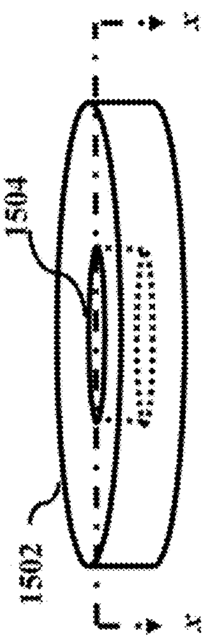


FIG. 17

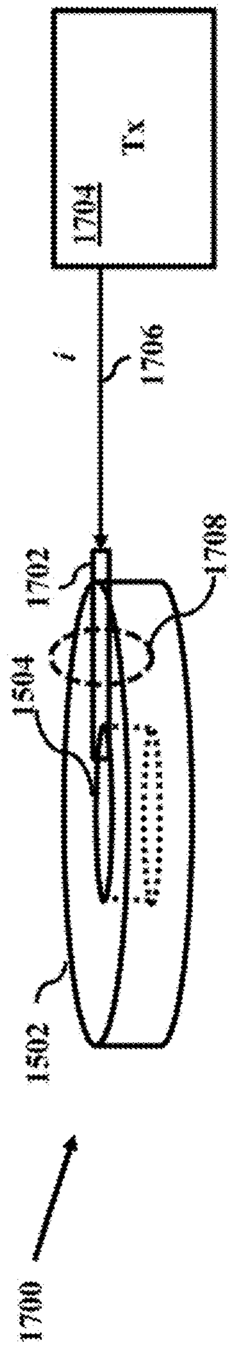


FIG. 27

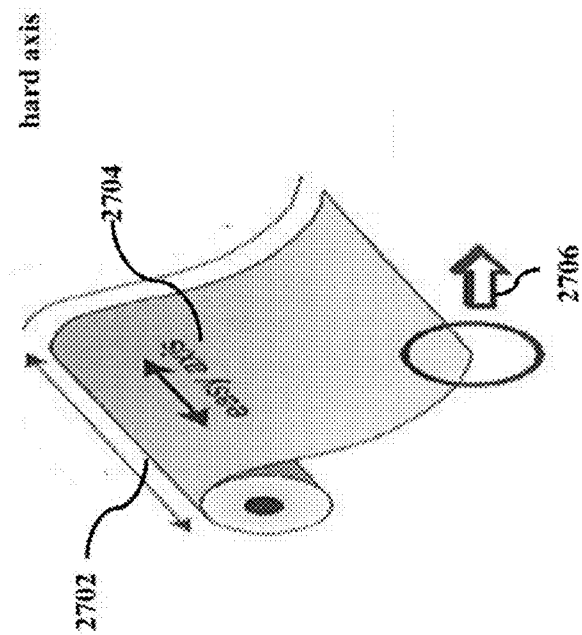


FIG. 18

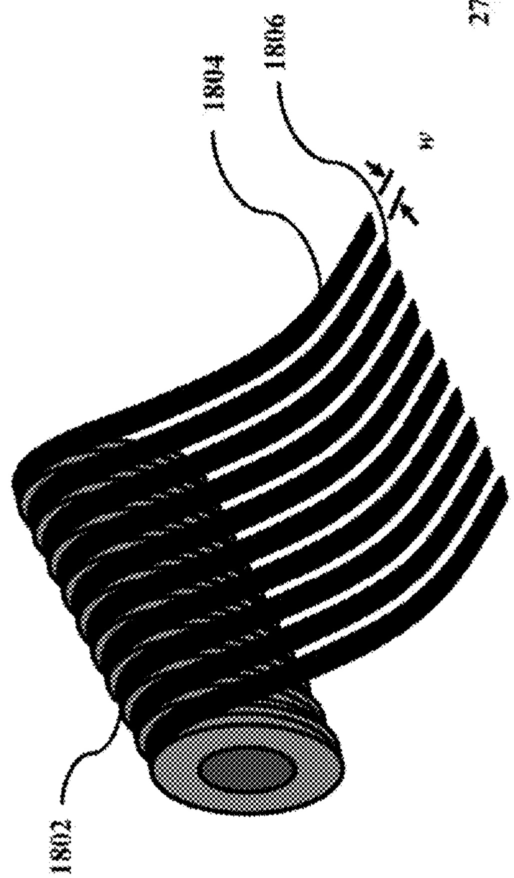


FIG. 19

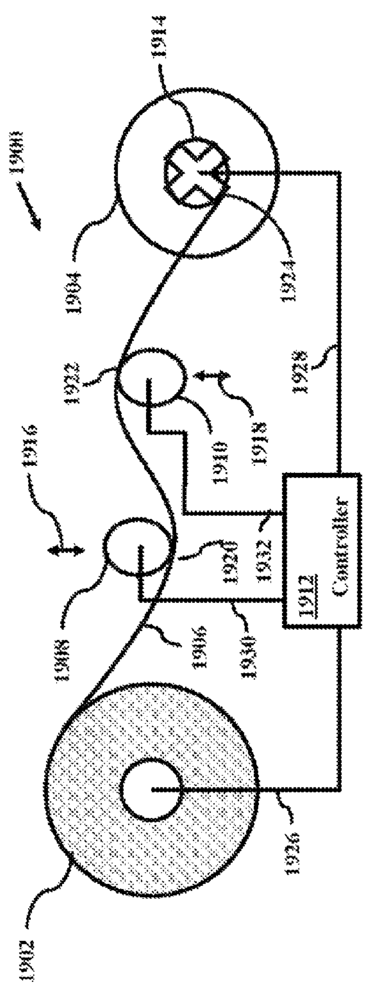

1900
1902
1904
1906
1908
1910
1912
Controller
1914
1916
1918
1920
1922
1924
1926
1928
1930
1932

FIG. 20

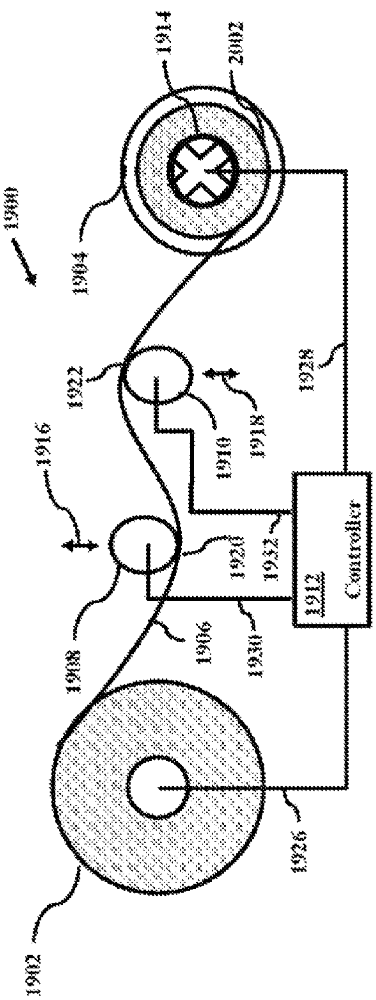

1900
1902
1904
1906
1908
1910
1912
Controller
1914
1916
1918
1920
1922
1926
1928
1930
1932
2002

FIG. 21

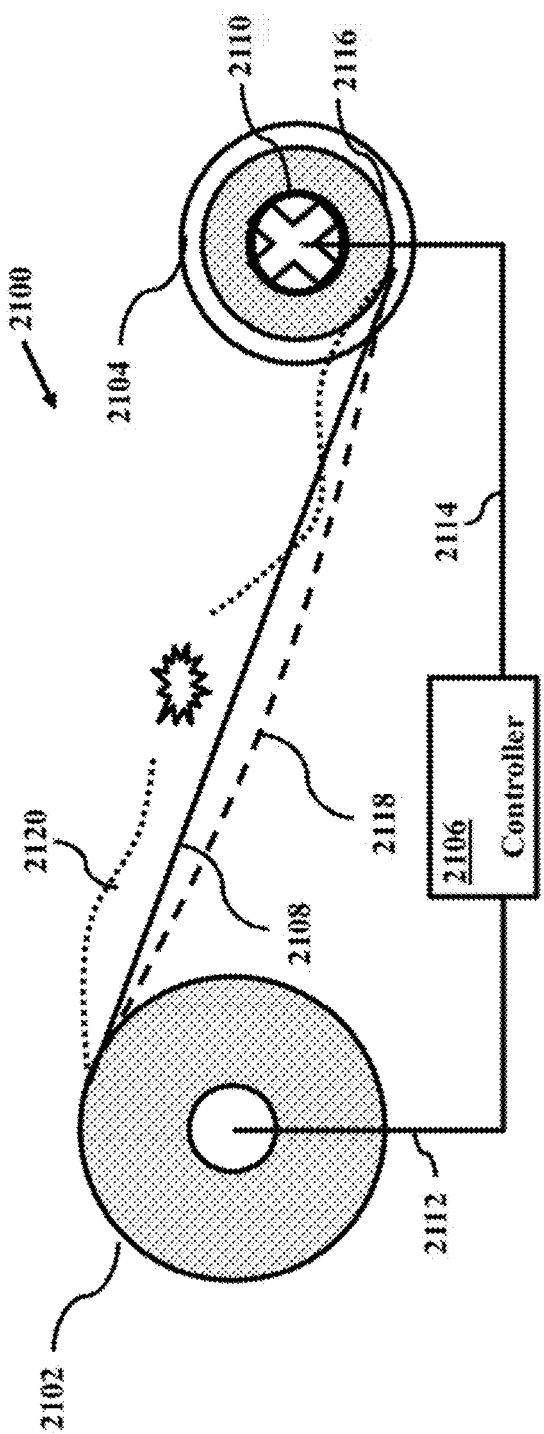

2100
2110
2116
2104
2114
2106
Controller
2118
2120
2108
2102
2112

FIG. 22

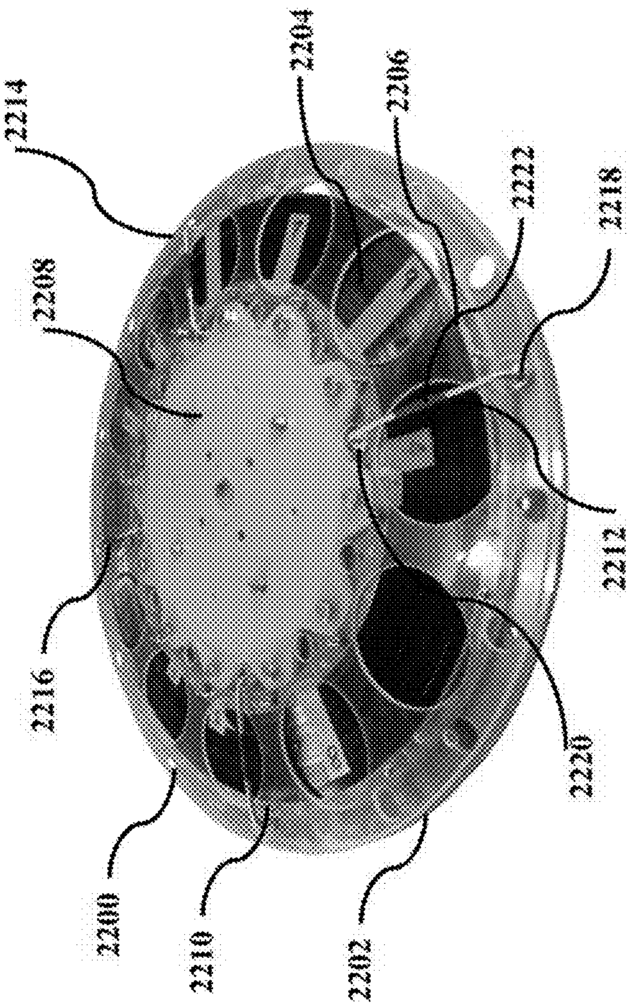


FIG. 24

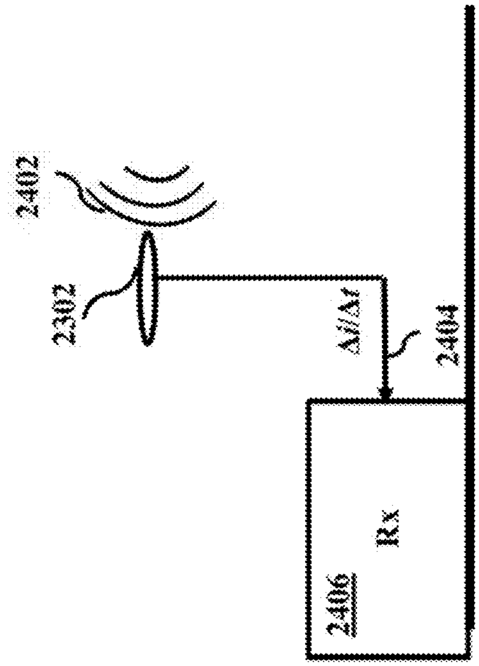


FIG. 23

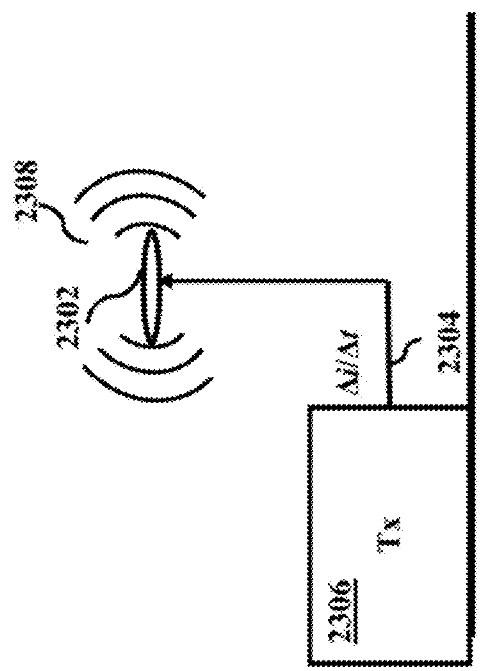
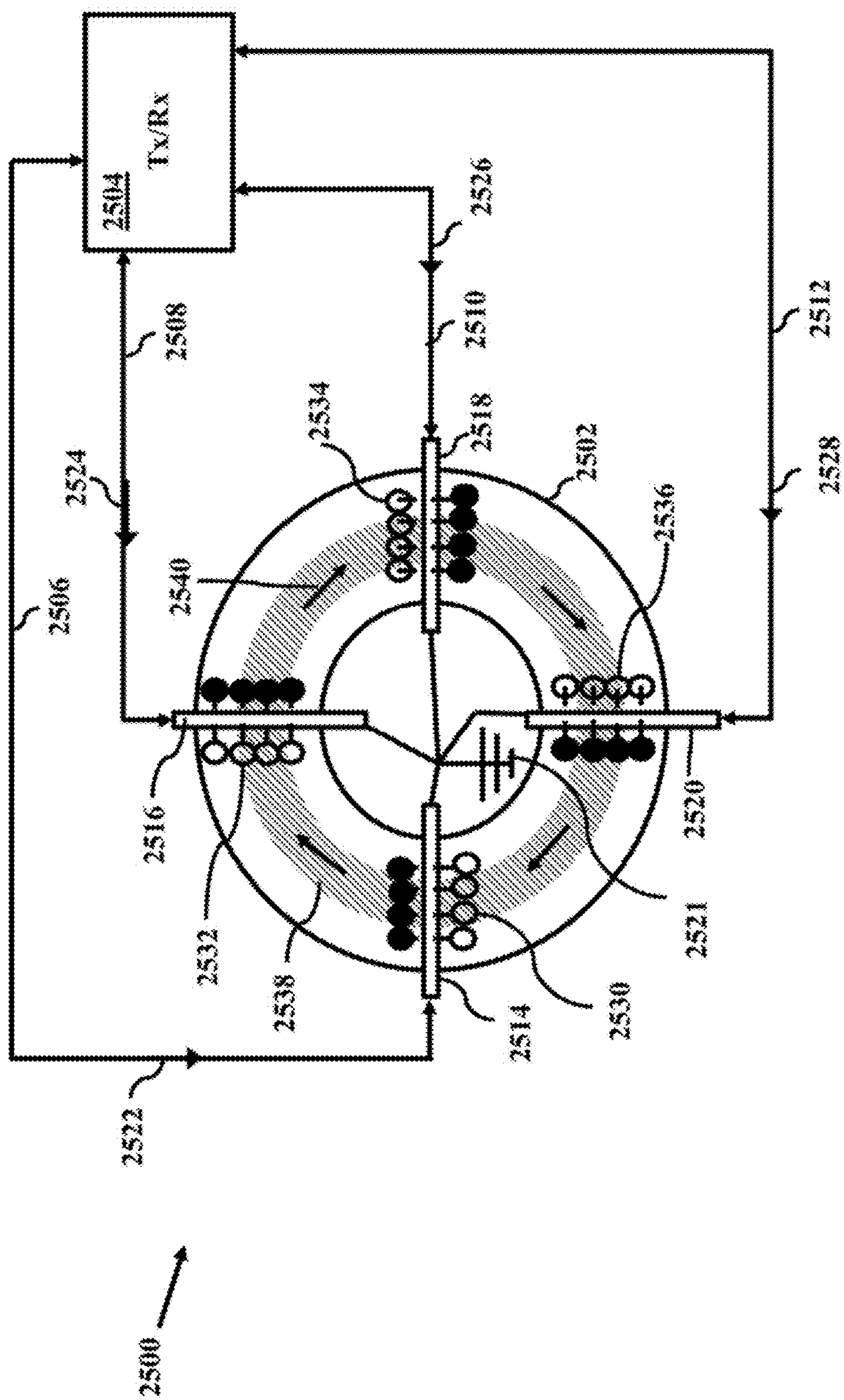


FIG. 25



2504
Tx/Rx
2506
2508
2510
2512
2514
2516
2518
2520
2521
2522
2524
2526
2528
2530
2532
2534
2536
2538
2540
2502
2500

FIG. 26

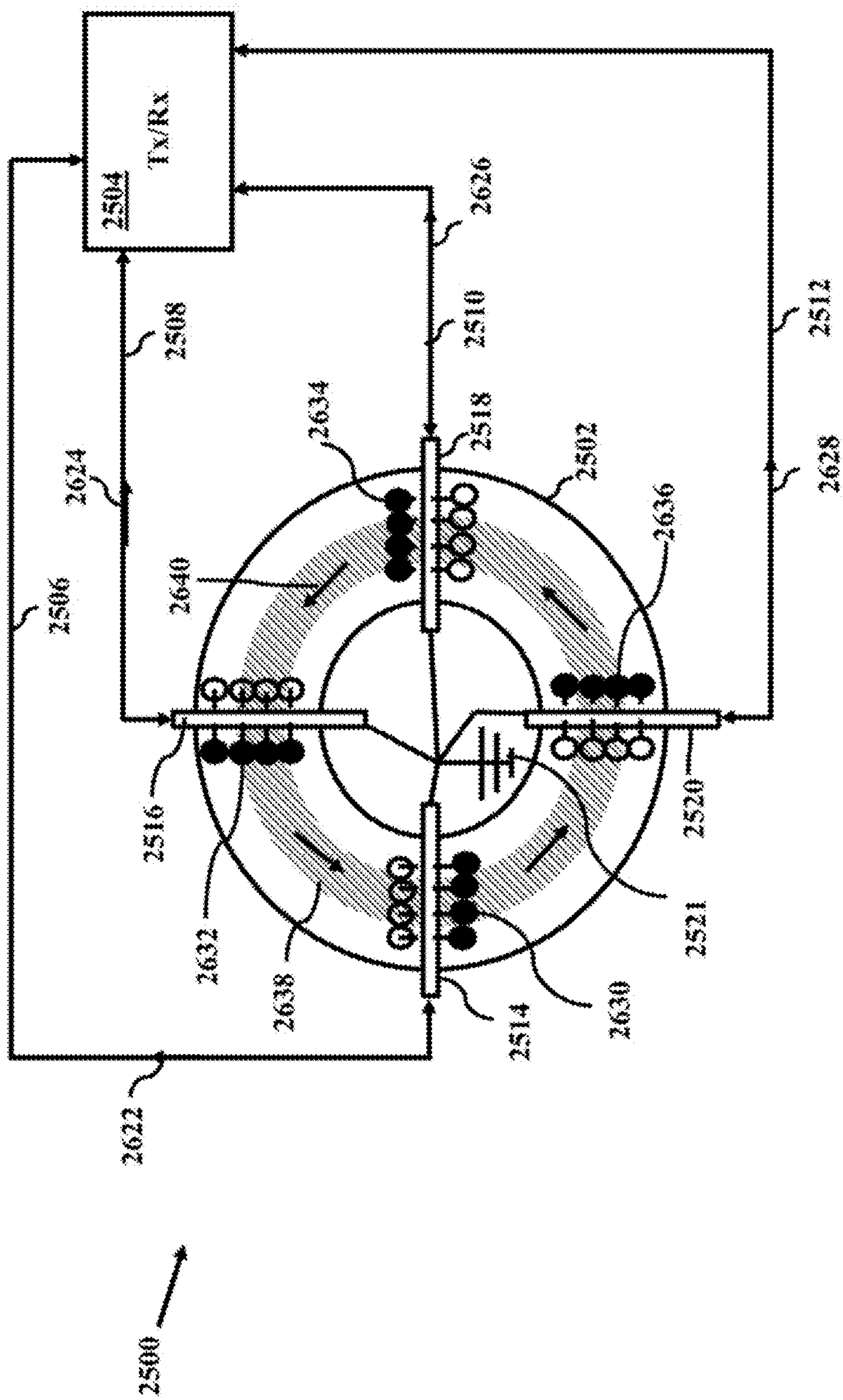

2504
Tx/Rx
2506
2508
2510
2512
2514
2516
2518
2520
2521
2502
2622
2624
2626
2628
2630
2632
2634
2636
2638
2640
2500

FIG. 28

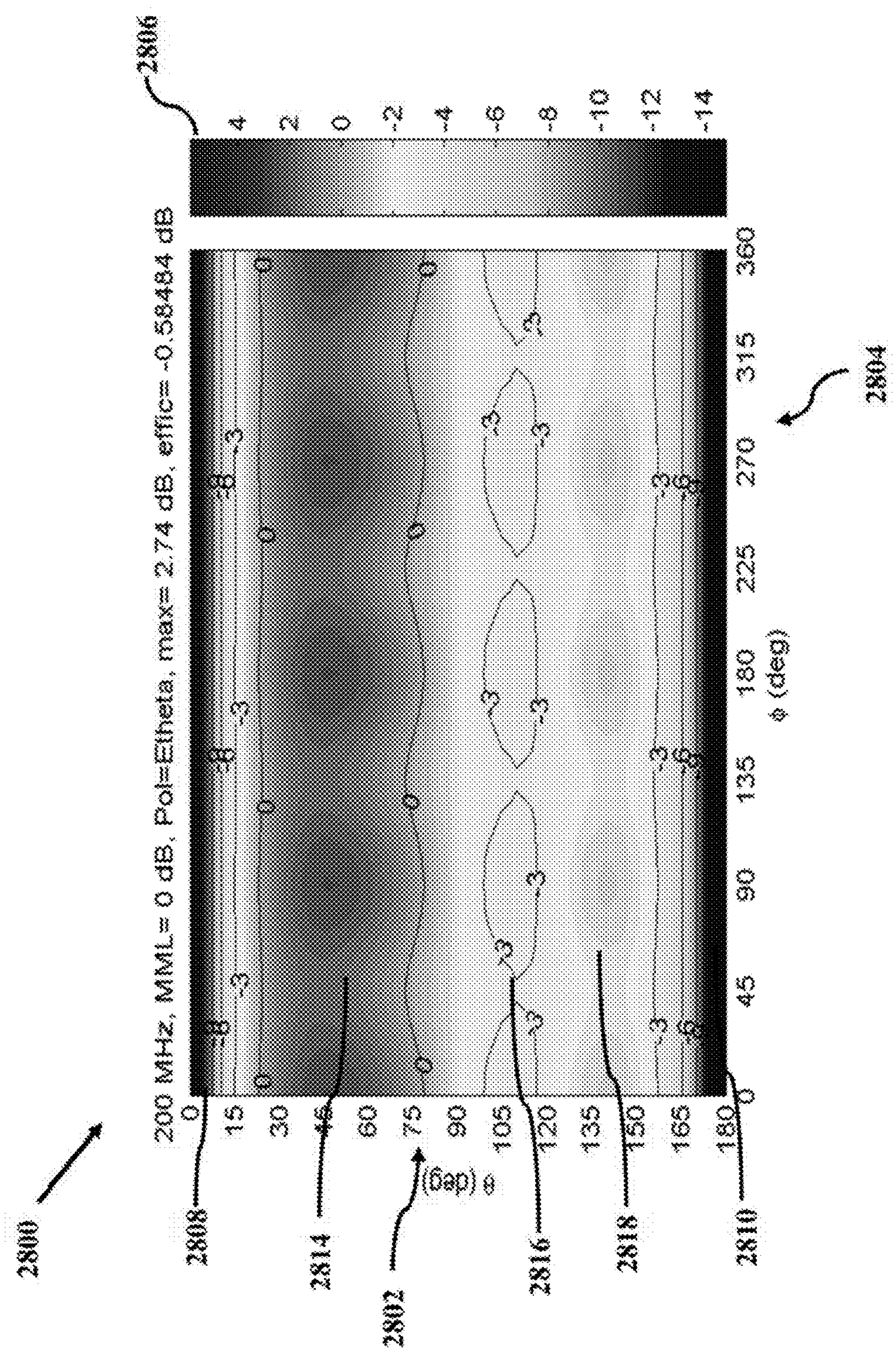
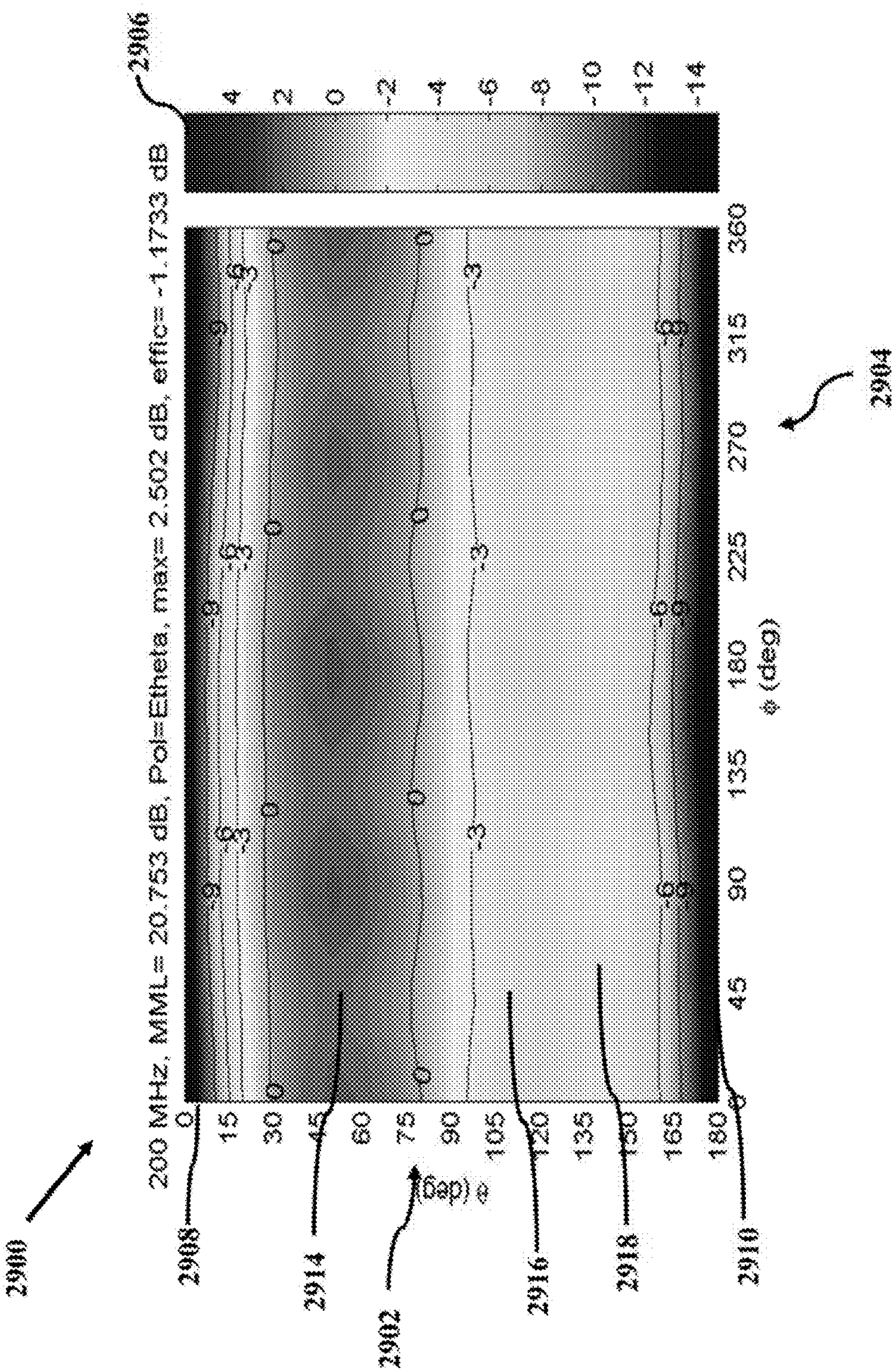

200 MHz, MML= 0 dB, Pol=Eltheta, max= 2.74 dB, effic= -0.58484 dB
θ (deg)
φ (deg)
2800
2802
2804
2806
2808
2810
2814
2816
2818

FIG. 29


200 MHz, MML= 20.753 dB, Pol=Etheta, max= 2.502 dB, effic= -1.1733 dB
θ (deg)
φ (deg)
0
15
30
45
60
75
90
105
120
135
150
165
180
0
45
90
135
180
225
270
315
360
4
2
0
-2
-4
-6
-8
-10
-12
-14
2900
2902
2904
2906
2908
2910
2914
2916
2918

MANDREL-WOUND MAGNETIC ANTENNA AND METHOD OF MAKING SAME

BACKGROUND

The present invention generally relates to antennas.

There has been a theoretical limit on the gain-bandwidth product that is achievable by an antenna. This limit applies whether the antenna is electric (i.e., charge-coupled) or magnetic (i.e., flux-coupled) in nature. Usually, increasing bandwidth (or decreasing Q) leads to a decrease in gain over the bandwidth of interest. There continue to be new results reporting ever closer encroachments on this limit.

Two types of conventional antennas will now be described with reference to FIGS. **1**-**8**.

FIG. **1** illustrates an electrical dipole **108** and the electric and magnetic fields associated therewith.

As shown in the figure, a z-axis **102**, an x-axis **106** and a y-axis **104** create a right-hand coordinate system. For purposes of discussion, in this example, electrical dipole **108** is disposed along z-axis **102**. Electrical dipole **108** has an electrical field, represented by sample lines **110**, resulting from the disposition of positive charge +Q in the positive portion of z-axis **102** and negative charge −Q in the negative portion of z-axis **102**. In accordance with the "right hand rule," electrical dipole **108** has a concentric magnetic field, represented by sample line **112**.

For purposes of discussion, consider the x-y plane where line **112** intersects lines **110**. In this plane, constant magnetic field strengths form continuous circles and follow a right hand vector orientation rule. The electric fields for electric dipole **108** are spatially orthogonal to the magnetic fields and their lines of force begin and end on the ends of the electric monopole (charge coupled). The electric fields and magnetic fields may be represented as vectors pairs, samples of which are shown as electric field vector **114** and magnetic field vector **116**, and electric field vector **118** and magnetic field vector **120**. The vector cross product of an electric field vector and magnetic field vector describe power flow that is radially outward from electric dipole **108**.

In many applications, an electric dipole may be used as an antenna, wherein the length of the electric dipole antenna may be equal to one half of the wavelength of the first harmonic of an electromagnetic wave that may be transmitted/received. In regards to Earth-bound antenna applications, e.g., a conventional radio station antenna, an electric dipole may be cut in half, to form an electric monopole, wherein the Earth approximates an infinite ground plane and ideal ground. An electric monopole antenna would provide field characteristics similar to an electric dipole associated with FIG. **1**. In particular, if the electric monopole were to correspond to the axis of the antenna, the power radiating from the antenna would radiate outward such that the length of the electric monopole antenna may equal one fourth of the wavelength of the first harmonic of an electromagnetic wave that may be transmitted/received. The field characteristics associated with an electric dipole (and the electric monopole) should be compared to a magnetic dipole, as described with reference to FIG. **2**.

FIG. **2** illustrates a magnetic dipole **208** and the electric and magnetic fields associated therewith.

As shown in the figure, a z-axis **202**, an x-axis **206** and a y-axis **204** create a right-hand coordinate system. For purposes of discussion, in this example, magnetic dipole **208** is disposed along z-axis **202**. Magnetic dipole **208** generates lines of electric field, represented by sample line **212**, that encircle it in the x-y plane. Magnetic dipole **208** generates lines of magnetic field, represented by sample lines **210**, that begin and end on surfaces having a net magnetic flux density. Again, the electric fields and magnetic fields may be represented as vectors pairs, samples of which are shown as electric field vector **214** and magnetic field vector **216**, and electric field vector **218** and magnetic field vector **220**.

The vector cross product of an electric field vector and magnetic field vector describe power flow that is radially outward from magnetic dipole **208**. It should be noted that if the magnitude of M equals the magnitude of $\eta_0 J$, then $E(M_D) = -H(J)$ and $H(M_D) = E(J)$, where J is the electric current density in A/m^2, M is the magnetic current density in V/m^2, E is the electric field intensity in V/m and H is the magnetic field intensity in A/m. In other words, because the electric and magnetic field vector pairs have a similar relationship in an electric dipole antenna and a magnetic dipole antenna, the outward radiating power flow is similar.

An electric monopole (or dipole) and a magnetic dipole may be used to create an antenna. An example of an electric dipole antenna will now be described with reference to FIGS. **3**-**4**.

FIG. **3** illustrates a conventional electric monopole antenna **302** using an electrical monopole to transmit a signal.

As shown in the figure, electric monopole antenna **302** is on a ground plane **304**. A transmitter **306** is arranged to provide a current **308** to electric monopole antenna **302**. Changes in current **308** generate transmission signals **310** from electric monopole antenna **302**.

Consider the situation where current **308** is disposed within electric monopole antenna **302** such that charges resemble the electric dipole discussed above with reference to FIG. **1**. In this manner, power will radiate outwardly from electric monopole antenna **302**. As the current alternates, the radiating power will similarly alternate, providing transmission signals **310**, which radiate outwardly. In this manner, electric monopole antenna **302** is an active device, transmitting a signal. Electric monopole antenna **302** may also perform as a passive device, receiving a signal.

FIG. **4** illustrates conventional electric monopole antenna **302** using an electrical monopole to receive a signal.

As shown in the figure, electric monopole antenna **302** is on a ground plane **304**. A receiver **406** is arranged to receive a current **408** from electric monopole antenna **302**. Received signals **410** generate changes in current **408**, which are provided to receiver **406**.

Signals **410** are electromagnetic waves. Electric monopole antenna **302** includes a conducting material. The interaction of signals **410** effect electrons within the conducting material of electric monopole antenna **302** to produce an overall charge therein. Consider the situation where such charges disposed within electric monopole antenna **302** resemble the electric dipole discussed above with reference to FIG. **1**. As the electromagnetic fields change within signals **410**, the magnitude and/or polarity of the charges within electric monopole antenna **302** similarly change. This change in the charge is current **408** (and similarly may be a change in current **408**). Receiver **406** is able to receive current **408**, and changes therein, to decode signals **410**. In this manner, electric monopole antenna **302** is a passive device, receiving a signal. As mentioned above, a magnetic dipole may be additionally be used as an antenna.

An example of a magnetic dipole antenna will now be described with reference to FIGS. **5**-**7**.

FIGS. **5**A-C illustrate a conventional stacked magnetic tile core magnetic dipole antenna.

As shown in FIG. **5**A, a stacked core **502** includes tile **504**, stacked on tile **506**, stacked on tile **508**, stacked on tile **510**. The material in each tile is used to increase magnetic field density.

As shown in FIG. **5**B, an electrical excitation component **512** is disposed perpendicular to the length of stacked core **502**.

As shown in FIG. **5**C, a transmitter **514** is arranged to provide a current **516** to electrical excitation component **512** and then to ground **518**. Current **516** generates concentric magnetic field lines, represented by sample dotted line **520**, around electrical excitation component **512**. The concentric magnetic field around electrical excitation component **512** induces magnetic fields within stacked core **502**, wherein the magnetic fields within stacked core **502** exit one end of stacked core **502** and return into the other end of stacked core **502** so as to make a closed loop of field lines, an example of which is represented as represented by field line **522**. Here the direction of propagation of the dynamic electromagnetic field associated with field line **522** is normal to the H vector and the E vector associated with field line **522**, as represented by arrow **524**.

In this example, field line **522** resembles the magnetic dipole discussed above with reference to FIG. **2**. In this manner, power will radiate outwardly from stacked core **502**.

FIG. **6** illustrates a conventional stacked magnetic tile core magnetic dipole antenna **602** using the magnetic dipole to transmit a signal.

As shown in the figure, conventional stacked magnetic the core magnetic dipole antenna **602** is disposed to receive a current **604** from a transmitter **514**. Changes in current **604** generate transmission signals **606** from magnetic dipole antenna **602**. In this example, antenna **602** includes stacked core **502** and electrical excitation component **512** of FIG. **5**.

Consider the situation where current **604** is fed to magnetic dipole antenna **602** such that generated magnetic dipole fields within stacked core **502** resemble the magnetic dipole fields associated with the magnetic dipole discussed above with reference to FIG. **2**. In this manner, power will radiate outwardly from magnetic dipole antenna **602**. As the current alternates, the radiating power will similarly alternate, providing transmission signals **606**, which radiate outwardly. In this manner, magnetic dipole antenna **602** is an active device, transmitting a signal. Magnetic dipole antenna **602** may also perform as a passive device, receiving a signal.

FIG. **7** illustrates conventional stacked magnetic tile core magnetic dipole antenna **602** using the magnetic dipole to receive a signal.

As shown in the figure, conventional stacked magnetic tile core magnetic dipole antenna **602** is arranged to receive signals **702**. Changes in signals **702** generate changes in a current **704**, which is provided to a receiver **706**.

Signals **702** are electromagnetic waves With additional reference to FIG. **5**, the interaction of signals **702** induces magnetic fields within the material of stacked core **502**. The magnetic fields within stacked core **502** induce a current in electrical excitation component **512**. As the electromagnetic fields change within signals **702**, the magnitude and/or polarity of the magnetic fields within stacked core **502** similarly change This change in the magnetic fields corresponds to current **704**. Receiver **706** is able to receive current **704**, and changes therein, to decode signals **702**, In this manner, magnetic dipole antenna **602** is a passive device, receiving a signal.

The physical and functional differences between an electric monopole antenna and a magnetic dipole antenna produce different transmission results. These differences will now be described with reference to FIG. **8**.

FIG. **8** is a graph **800** illustrating gain as a function of angle for an electric monopole antenna and a stacked antenna.

As shown in the figure, graph **800** includes a y-axis **802** measuring gain in dB, and an x-axis **804** measuring an angle in degrees (from zenith, or along the axis of the electric monopole or magnetic dipole). Graph **800** includes a function **806** and a function **808**.

Function **806** corresponds to vertical elevation cut of the radiation performance of a vertical electric monopole antenna **822**, as shown to the left of graph **800**. Function **806** additionally corresponds to fields discussed above with reference to FIG. **1**. Function **806** has a maximum gain at approximately 45° (from zenith) indicated at point **810** and approximately −45° (from zenith) indicated at point **812**. The gain drops at 0° (zenith) indicated at point **814**, at −180° (nadir) shown at point **816** and at 180° (nadir, not shown), because the radiation is not in the direction along the axis of the electric monopole.

Function **808** corresponds to a vertical elevation cut of the radiation performance of a horizontal magnetic dipole antenna **824**, as shown to the right of graph **800** Function **808** additionally corresponds to fields discussed above with reference to FIG. **2**. The field distribution and polarization is exactly what one would expect from a magnetic dipole antenna. Function **808** has a maximum gain at approximately 0° (zenith) indicated at point **818**. The gain drops at approximately −135° indicated at point **820**, and at approximately 135° (not shown), because the horizon is at ±90°, and very little power radiates behind the finite ground plane. Only a small amount of power is diffracted around the ground plane edges, creating the −10 dBi backlobe at nadir.

As shown in FIG. **8** the gain as a function of the angle from azimuth is different for a magnetic dipole antenna as compared to that of an electric monopole antenna. These different gain functions may have different optimal applications. On the other hand, a tall narrow stick-like shape of an electric monopole antenna is quite different from the shape of a stacked-core, bar shape of a magnetic dipole antenna, for example as shown in FIG. **5**C. These different shapes may have different optimal applications. There may be situations where the gain function of an electric monopole antenna is desired, but the smaller height of the magnetic dipole antenna is also desired.

What is needed is an antenna that provides a transmission function similar to a conventional electric monopole antenna, but without the large height associated with the conventional electric monopole antenna.

BRIEF SUMMARY

The present invention provides an antenna that has a transmission function similar to a conventional electric monopole antenna, but without the large height associated with the conventional electric monopole antenna.

An aspect of the present invention is drawn to an antenna including an electrical excitation component and a core component. The electrical excitation component has an input, an output and a conducting component. The conducting component is disposed between the input and the output and can conduct current from the input to the output. The core component has a wound magnetic film having a substrate and a magnetic material layer. The core component can have a magnetic current loop induced therein. The electrical excitation component is arranged such that concentric magnetic fields associated with current conducted through the electri-

cal excitation component are additionally associated with a magnetic current loop within the core component.

Additional advantages and novel features of the invention are set forth in part in the description which follows, and in part will become apparent to those skilled in the art upon examination of the following or may be learned by practice of the invention. The advantages of the invention may be realized and attained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

BRIEF SUMMARY OF THE DRAWINGS

The accompanying drawings, which are incorporated in and form a part of the specification, illustrate an exemplary embodiment of the present invention and, together with the description, serve to explain the principles of the invention. In the drawings:

FIG. **1** illustrates an electrical dipole and the electric and magnetic fields associated therewith;

FIG. **2** illustrates a magnetic dipole and the electric and magnetic fields associated therewith;

FIG. **3** illustrates a conventional electric monopole antenna using an electrical dipole to transmit a signal;

FIG. **4** illustrates the conventional electric monopole antenna, of FIG. **3**, using an electrical dipole to receive a signal;

FIGS. **5**A-C illustrate a conventional stacked antenna using a magnetic dipole:

FIG. **6** illustrates the conventional stacked antenna, of FIG. **5**C, using the magnetic dipole to transmit a signal;

FIG. **7** illustrates the conventional stacked antenna, of FIG. **5**C, using the magnetic dipole to receive a signal;

FIG. **8** is a graph illustrating gain as a function of angle for an electric monopole antenna, a stacked free-space antenna, and a stacked antenna;

FIG. **9** illustrates a side view of an example stacked film for use in an antenna and a conventional stacked magnetic tile core for use in an antenna;

FIG. **10** illustrates a side view an example stacked film for use in a stacked film antenna;

FIG. **11** illustrates a side view an example stacked film for use in a stacked film antenna;

FIG. **12** illustrates a roll of magnetic film to be cut to form a stacked film core;

FIG. **13** illustrates a side view of stacked films used in formation of a stacked film core;

FIG. **14** illustrates a magnetic loop and the electric and magnetic fields associated therewith;

FIG. **15** illustrates an example core component in accordance with aspects of the present invention;

FIG. **16** illustrates a cross sectional view of the core component of FIG. **15**, as cut through line x-x;

FIG. **17** illustrates an example transmission system in accordance with aspects of the present invention;

FIG. **18** illustrates an example roll of magnetic film to be cut to form a core component in accordance with aspects of the present invention;

FIG. **19** illustrates an example system, at time t_0, for forming a core component in accordance with aspects of the present invention;

FIG. **20** illustrates the example system of FIG. **19**, at time t_1, for forming a core component in accordance with aspects of the present invention;

FIG. **21** illustrates another example system, at time t_1, for forming a core component in accordance with aspects of the present invention;

FIG. **22** illustrates an example magnetic loop antenna in accordance with aspects of the present invention;

FIG. **23** illustrates a magnetic loop antenna using a magnetic loop to transmit a signal in accordance with aspects of the present invention;

FIG. **24** illustrates the magnetic loop antenna of FIG. **23**, using a magnetic loop to receive a signal in accordance with aspects of the present invention;

FIG. **25** illustrates a schematic view of an example magnetic loop antenna communication system in accordance with aspects of the present invention, wherein a magnetic loop is traveling in a clockwise direction;

FIG. **26** illustrates a schematic view of the example magnetic loop antenna communication system of FIG. **25**, wherein a magnetic loop is traveling in a counter-clockwise direction;

FIG. **27** illustrates another example roll of magnetic film to be cut to form a core component in accordance with aspects of the present invention;

FIG. **28** is a graph illustrating gain as a function of two angles for an example conventional monopole antenna; and

FIG. **29** illustrates is a graph illustrating gain as a function of two angles for an example magnetic loop antenna in accordance with aspects of the present invention.

DETAILED DESCRIPTION

The present invention is drawn to a magnetic loop antenna that behaves as a mathematical dual of a conventional electric monopole antenna. Lately, the use of magneto-dielectric materials is reported to show promise for increasing the antenna gain-bandwidth product. Others have presented a low-loss, low-profile antenna based on a lossy magneto-dielectric material: a Ni—Zn ferrite operating in its dispersion region. The antenna behaves as a magnetic dipole and a radiation efficiency of almost 65% is obtained at a frequency for which the loss tangent of the material is greater than 10.

Aspects of the present invention are drawn to a magnetic loop antenna that includes a core of multiple magneto-dielectric material layers. Example embodiments include material layers between 0.1 microns and 52 microns (i.e., 0.004 mils and 2 mil, a layer thickness range of more than 500:1). In some embodiments, each material layer is homogeneous and isotropic and may be a metal, metal alloy, dielectric or magneto-dielectric. In some embodiments, each material layer is disposed on a substrate. The material layers may be sputtered onto the substrate via cathode and anode, or otherwise chemically deposited on either constitutive layers or sacrificial layers that are removed during finishing. The final assembly has the characteristics of an inhomogeneous material with desired anisotropic characteristics. These materials can be shaped into many different geometries suitable for obtaining various impedance bandwidths and desired electric and magnetic field orientations. The material shapes are excited by using magnetic flux coupling loops that convert an electric voltage on a coaxial line (volts) to magnetic flux (volt-sec) in the material.

FIG. **9** illustrates a side view of a conventional stacked magnetic tile core **900** for use in an antenna and a theoretical stacked film **902** for use in an antenna.

As shown in the figure, conventional stacked magnetic tile core **900** includes a plurality of magnetic material tiles, an example of which is indicated as tile **904**. An exploded view of circular portion **906** of theoretical stacked film **902** is shown as circular portion **908**. An exploded view of circular portion **910** is shown as circular portion **912**.

Stacked magnetic tile core **900** provides magnetic field lines within each tile, in a direction along the length of the tiles. In this example, let each magnetic material tile in stacked magnetic tile core **900** be 0.25 in. As the thickness of each tile increases, there is a corresponding increase in unwanted eddy currents. These eddy currents produce heat within the tiles, thus reducing the overall Q factor of the stacked magnetic tile core **900**. The Q factor can generally be considered the quality of resistance to resonance, wherein a higher Q factor translates into a better magnetic core component for an antenna. Therefore, one way to increase the Q factor is to decrease the thickness of each magnetic tile. This may be accomplished by using films as opposed to tile, which leads to the theoretical stacked film **902**.

Stacked film **902** includes a plurality of film layers, an example of which is labeled as **914**. In this example, let each film layer be approximately 25 microns thick. Because each film in stacked film **902** is orders of magnitude less in thickness as compared to each magnetic material tile in stacked magnetic tile core **900**, stacked film **902** would have orders of magnitude less eddy currents. As such, stacked film **902** would theoretically have a much higher Q than stacked magnetic tile core **900**.

FIG. **10** illustrates a side view of an example film **1002** for use in a theoretical stacked film antenna. Film **1002** includes a layer **1004** of magnetic material disposed on a substrate **1006**. In this example, layer **1004** and substrate. **1006** have an equal thickness. Substrate provides structural support for layer **1004**. Further, when film **1002** is stacked upon another similar film, substrate **1006** separates layer **1004** from the adjacent magnetic material layer. This separation insulates the two magnetic. material layers, which prevents adjacent conducting layers from touching and conducting, between each other. As such, any generated eddy currents are trapped within a single layer of conductor. The separation is important, yet the actual thickness of substrate **1006** does not need to equal layer **1004**.

FIG. **11** illustrates a side view of an example film **1102** for use in a stacked film antenna. Film **1102** includes a layer **1104** of magnetic material disposed on a substrate **1106**. In this example, layer **1104** is much thicker than substrate **1106**. Again, substrate provides separation of adjacent magnetic material layers, when the films are stacked. However, a bulk of the thickness of film **1102** corresponds to the magnetic material such that a large amount of magnetic field lines may be generated. Minimization of substrate layer thickness achieves greater magnetization but must be traded with its ability to support sputtered films while under tension.

Fabrication of a theoretical stacked film core for use in a magnetic dipole antenna will now be described with reference to FIGS. **12**-**13**.

FIG. **12** illustrates a roll **1202** of magnetic film to be cut to form a stacked film core.

As shown in the figure, a line **1208** indicates where magnetic film of roll **1202** will be cut, whereas portion **1204** and portion **1206** have already been cut. In this example roll **1202** has a length l, and each cut portion will have a width w, such that a resulting stacked film core would have a length l and width w. Currently, there is only one machine in the world can deposit a magnetic material as a coating at 0.1 microns in industrial quantities, and the film manufacturer only makes the film in one width. The length of the roll, the thickness of the film, and the thickness of the metal coating are buyer-specified, within the operational bounds established by the factory.

By stacking up the film, e.g., portions **1204** and **1206**, a bar core may provide a net magnetization, due to the volume (height) dilution factor of film-to-coating thickness. From required known design parameters, the required cross-section of the antenna may be determined. One possible implementation would be to stack up individual sheets of material and bond them together then cut out an antenna from that stack. This is wasteful of the (expensive) raw material. Further, there are problems with stacking the fragile portions of film, as will now be described with reference to FIG. **13**.

FIG. **13** illustrates a side view of films **1302** and **1304** used in formation of a stacked film core.

Let the thickness of each of films **1302** and **1304** be on the order of 25 microns. Because these films are so thin and because of an inherent tension obtained from the roll processing steps, they tend to curl at the edges or crinkle, thus leaving spaces **1306** and **1308** between them in an attempt to stack. These spaces negatively affect the overall ability of each layer to couple with outside magnetic fields. It is this reason that the stacked film core discussed above with respect to FIGS. **9**-**12** is referred to as a "theoretical" stacked film core. In particular, it is impractical to actually fabricate. Nevertheless, the magnetic film layers may be stacked in another way to form a magnetic antenna.

In accordance with aspects of the present invention, a magnetic loop core formed of a plurality of magnetic layers may be used to create an antenna. An example of magnetic loop antenna in accordance with aspects of the present invention will now be described with reference to FIGS. **14**-**26**.

FIG. **14** illustrates a magnetic loop **1408** and the electric and magnetic fields associated therewith.

As shown in the figure, a z-axis **1402**, an x-axis **1406** and a y-axis **1404** create a coordinate system. Magnetic loop **1408** is disposed about z-axis **1402** on the plane made by x-axis **1406** and y-axis **1404**. Magnetic loop **1408** has an associated electric field, represented by sample lines **1410**, which have a concentric magnetic field, represented by sample line **1412**. A resulting E, H vector pair is shown as lines **1414** and **1416** respectively, and another resulting E, H vector pair is shown as lines **1418** and **1420**, respectively. The vector cross product of E and H describe power flow that is radially outward from magnetic loop **1408**.

The fields of magnetic loop **1408** are identical to those of electric monopole **108** of FIG. **1**, if M_L=J. Of particular interest is the case when magnetic loop **1408** is placed on a perfect electric conductor (PEC) ground plane. A PEC is a theoretical abstraction. It is: 1) perfectly conducting, which means zero loss and zero skin depth; and 2) it extends to infinity. In this case, any voltage induced across the PEC will produce an infinite current, which will exactly cancel the applied voltage. Thus the tangential voltage vector across any PEC shall always be zero. Tangential magnetic currents may flow against a PEC, and this is achieved with an antenna in accordance with the present invention. In that case, loop **1408** becomes equivalent to an electric monopole excited perpendicular to the perfect electric ground plane.

In accordance with aspects of the present invention, a magnetic loop may be implemented via a magnetic core component. This will now be described with reference to FIGS. **15**-**17**.

FIG. **15** illustrates an example core component **1502** in accordance with aspects of the present invention. Core component **1502** has a circular shape with a hole **1504** at its center.

FIG. **16** illustrates a cross sectional view of core component **1502** of FIG. **15**, as cut through line x-x.

As shown in FIG. **16**, core component **1502** has a cross-sectional portion **1602** and and a cross-sectional portion **1604** about hole **1504**.

Core component **1502** includes wound magnetic film, one layer of which is labeled as **1602**. Each layer includes a substrate and a magnetic material layer, similar to that discussed above with reference to FIGS. **10-11**. As a result of this structure, core component **1502** is able to have a magnetic current loop induced therein. In FIG. **16**, a magnetic loop is indicated in layer **1602** as dot **1606** and corresponding circle **1608** shown in cross-sectional portion **1604**. In this example, dot **1606** represents the magnetic field loop entering the page, whereas circle **1608** represents the loop leaving the page, wherein the magnetic field loop would have a clockwise polarity as viewed with reference to FIG. **15**.

FIG. **17** illustrates an example transmission system **1700** in accordance with aspects of the present invention.

As shown in the figure, transmission system **1700** includes core component **1502**, an electrical excitation component **1702** and a transmission component **1704**. Transmission component is arranged to provide a current **1706** to electrical excitation component **1702**. Current passing through electrical excitation component **1702** generates associated concentric magnetic fields, a sample of which is indicated by dotted line **1708**. The concentric magnetic fields couple into core component **1502** to induce a magnetic field loop within core component **1502**. Magnetic field loops within core component **1502** may be exploited to transmit or receive electromagnetic signals as an antenna. Before discussing how core component **1502** may be used to transmit/receive signals, a method of making a magnetic loop core component will be discussed.

An example method of making a magnetic loop antenna in accordance with aspects of the present invention will now be described with reference to FIGS. **18-22**.

FIG. **18** illustrates an example roll **1802** of magnetic film as cut to form a core component in accordance with aspects of the present invention.

In an example embodiment, the magnetic film of roll **1802** includes a magnetic material layer disposed on a substrate layer similar in structure to the films discussed above with reference to FIGS. **9-10**. Non-limiting examples of the magnetic material layer include one of the group consisting of NiZn ferrite. Co_2Z hexaferrite, CoFeSiNoB ferromagnetic metal alloy, CoZrNb ferromagnetic metal alloy, and combinations thereof.

Roll **1802** may be a rolled sheet of film as discussed above with reference to FIGS. **10-11**. Roll **1802** is cut along lines perpendicular to the axis of roll **1802** into strips, examples of which are labeled **1804** and **1806**. This method of cutting roll **1802** is contrary to the method discussed above with reference to FIG. **12**, wherein roll **1202** was cut along lines parallel with the axis of roll **1202**.

Each strip has a width corresponding to the height of a core component, as will be described in more detail later. In this non-limiting example, each strip of roll **1802** has an equal width w. However in other examples, many different width strips may be cut in order to form core components having different heights. Once a sheet of film has been cut, a core component may be fabricated. An example method of which will now be described in greater detail with reference to FIGS. **19-20**.

FIG. **19** illustrates an example system **1900**, at time t_0, for forming a core component in accordance with aspects of the present invention.

As shown in the figure, system **1900** includes a roll **1902** of magnetic film, a receiving blank **1904**, a tension roller **1908**, a tension roller **1910** and a controller **1912**. Receiving blank **1904** includes a mandrel **1914**, centrally located thereon.

Roll **1902** is a roll of film to be used to fabricate a magnetic loop core. Roll **1902** is rotatable, so as to unroll film **1906** therefrom. Let roll **1902** be a film of the type discussed above with reference to FIGS. **10-11**, and cut from a sheet of a type discussed above with reference to FIG. **18**. In one example, roll **1902** may be strip **1804** repackaged into a roll of film after being sliced from roll **1802**. Roll **1902** may additionally be a plurality of strips that have been joined by any known method, non-limiting examples of which include using adhesives, heating, and combinations thereof. In another example, roll **1902** may include strip **1804** joined with strip **1806**, so as to double the total length of film.

Since the magnetic antennas will be fabricated by standing the films on edge, the width w of the cut film is chosen to be equal to the vertical antenna height as desired. In this example, the resulting magnetic loop core component will have a height equal to w of strip **1804**.

Tension roller **1908** can rotate and is able to move up and down in a direction indicated by double arrow **1916**. Film **1906** is able to pass under rolling tension roller **1908** at location **1920**. Tension roller **1910** can rotate and is able to move up and down in a direction indicated by double arrow **1918**. Film **1906** is able to pass over rolling, tension roller **1910** at location **1922**, As such, the tension of magnetic film **1906** may he managed by moving either or both of tension roller **1908** and tension roller **1910** in a respective direction. Tension roller **1908** and tension roller **1910** are non-limiting examples of known tension management devices. Any known device for maintaining a predetermined tension may be used so as to prevent film **1906** from buckling or curling as it winds around mandrel **1914**.

Receiving blank **1904** is rotatable. Mandrel **1914** is able to have an end of film **1906** anchored thereto at location **1924**, by any known anchoring method or system, non-limiting examples of which include an adhesive, magnetically, a slit for which film **1906** may be inserted, or a grabbing mechanism. Mandrel **1914** may be any shape. In this non-limiting example embodiment, mandrel **1914** is circular.

Film **1906** is unrolled from roll **1902**, is fed by tension roller **1908**, is fed by tension roller **1910** and is anchored onto mandrel **1914**.

Controller **1912** is able to: control roll **1902** via communication channel **1926**; control receiving blank **1904** via communication channel **1928**; control tension roller **1908** via communication channel **1930** and control tension roller **1910** via communication channel **1932**. Each of communication channels **1926**, **1928**, **1930** and **1932** may be any known type of wired or wireless communication channel.

Controller **1912** is able to control the rate at which roller **1902** unrolls the film and is able to control the rate at which receiving blank **1904** winds the film. Controller **1912** is additionally able to control the amount of movement of tension roller **1908** along the direction of double arrow **1916** and to control the amount of movement of tension roller **1910** along the direction of double arrow **1918**.

FIG. **20** illustrates example system **1900**, at time t_1, for forming a core component in accordance with aspects of the present invention.

As film **1906** unrolls from roll **1902**, it eventually winds around mandrel **1914** to from a magnetic loop core, an incomplete portion of which is indicated in FIG. **20** as core portion **2002**. Controller **1912** positions tension rollers **1908** and **1910** so as to ensure film **1906** does not crinkle, fold or bunch as it is wound about mandrel **1914**. As such, this method of creating layers of film avoids the problems associated with the stacked film core discussed above with reference to FIG. **13**. Further, inter-layer adhesives are not needed to maintain core component by winding around mandrel **1914**. This is a beneficial aspect, as inter-layer adhesives are not desirable because they decrease the overall Q of the core component. Once the core component is complete, e.g. the number of windings reaches a total required thickness in the core component, locally arranged electromagnets (not shown) may be used to hold a film to its desired mandrel form. At that point, a compression form may be used to hold the wound core component on mandrel **1914**.

The magnetic core component winding process described above with reference to FIGS. **19-20** may produce a less than optimal magnetic core component. In particular, tension rollers **1908** and **1910** contacting film **1906** may damage film **1906**. Further any particulates that accumulate on tension rollers **1908** and **1910** may be transferred to film **1906**, which will decrease the homogeneity of the final magnetic core component. To avoid these problems, another example method of manufacturing a magnetic core component may be implemented, as will now be discussed with reference to FIG. **21**.

FIG. **21** illustrates an example system **2100**, at time t_1, for forming a core component in accordance with aspects of the present invention.

As shown in the figure, system **2100** includes a roll **2102** of magnetic film, a receiving blank **2104** and a controller **2106**. Receiving blank **2104** includes a mandrel **2110**, centrally located thereon.

Roll **2102** is a roll of film to be used to fabricate a magnetic loop core and is similar to roll **1902** discussed above with reference to FIGS. **19-20**. Roll **2102** is rotatable, so as to unroll film **2108** therefrom.

Receiving blank **2104** is similar to receiving blank **1904** discussed above with reference to FIGS. **19-20**. Similarly, mandrel **2116** is similar to mandrel **1914** discussed above with reference to FIGS. **19-20**.

Film **2108** is unrolled from roll **2102** and is anchored onto mandrel **2110**. In this manner, system **2100** differs from system **1900** in that system **2100** does not include tension rollers.

Controller **2106** is able to control roll **2102** via communication channel **2112** and to control receiving blank **2104** via communication channel **2114**. Each of communication channels **2112** and **2114** may be any known type of wired or wireless communication channel.

Controller **2106** is able to detect tension of film **2108** as it is being unrolled from roll **2102** and control the rate at which roller **2102** unrolls the film. Further, controller **2106** is able to detect tension of film **2108** as it is being rolled onto receiving blank **2110** and is able to control the rate at which receiving blank **2110** winds the film.

As film **2108** unrolls from roll **2102**, it eventually winds around mandrel **2110** to from a magnetic loop core, an incomplete portion of which is indicated in FIG. **21** as core portion **2116**.

Controller **2106** constantly measures the tension on each of roll **2102** and receiving blank **2110** and accordingly adjusts the rotation rate of roll **2102** and the rotation rate of receiving blank **2110** to ensure that film **2108** is within a predetermined acceptable tension thresholds. If the tension of film **2108** drops below a first predetermined acceptable tension threshold, then the film may slack as shown by dashed line **2118**. Slack in film **2108** may increase the likelihood of crinkling, twisting or curling of film **2118** while winding about receiving blank **2110**, which will decrease the overall Q of the core component. If the tension of film **2108** rises above a second predetermined acceptable tension threshold, then the film may break as shown by dotted line **2120**. A break in the film may require fabrication of an entirely new core or a splicing step, which will decrease the overall Q of the core component.

This method of creating layers of film avoids the use of tension rollers, thus avoiding the problems associated with the method discussed above with reference to FIGS. **19-20**.

Once the core component is wound, electrical excitation components, e.g., flux coupling loops, may then be added after the winding process. These electrical excitation components may be connected to a power distribution network which can achieve any number of desired modes with the antenna.

FIG. **22** illustrates an example magnetic loop antenna **2200** in accordance with aspects of the present invention.

As shown in the figure, antenna **2200** includes a back support **2202**, a core component **2204**, a front support **2206**, a mandrel **2208**, an electrical excitation component **2210**, an electrical excitation component **2212**, and electrical excitation component **2214** and an electrical excitation component **2216**.

In this example, back support **2202** corresponds to receiving blank **1904** of FIG. **19** and mandrel **2208** corresponds to mandrel **1914** of FIG. **19**. Front support **2206** encloses core component **2204**. Although electrical excitation components **2210**, **2212**, **2214** and **2216** are used in this example, any number of electrical excitation components may be used.

Each of electrical excitation components **2210**, **2212**, **2214** and **2216** has an input, an output and a conducting component. For example, electrical excitation component **2212** has an input **2218**, an output **2220** and a conducting component **2222**. Conducting component **2222** is disposed between the input and the output and is able to conduct current from the input to the output. In this manner, electrical excitation component **2212** is able to induce a magnetic loop within core component **2204** in a manner similar to that discussed above with reference to FIG. **17**.

An example method of operating a magnetic loop antenna in accordance with aspects of the present invention will now be described with reference to FIGS. **23-26**.

FIG. **23** illustrates a magnetic loop antenna **2302** using a magnetic loop to transmit a signal in accordance with aspects of the present invention.

As shown in the figure, magnetic loop antenna **2302** is disposed to receive a current **2304** from a transmitter **2306**. Changes in current **2304** generate transmission signals **2308** from **2302**.

Consider the situation where current **2304** is fed to magnetic loop antenna **2302** such that generated magnetic loop within the core component resembles the magnetic loop discussed above with reference to FIG. **14**. In this manner, power will radiate outwardly from magnetic loop antenna **2302**. As the current alternates, the radiating power will similarly alternate, providing transmission signals **2308**, which radiate outwardly. In this manner, magnetic loop antenna **2302** is an active device, transmitting a signal. Magnetic loop antenna **2302** may also perform as a passive device, receiving a signal.

FIG. **24** illustrates magnetic loop antenna **2302** using a magnetic loop to receive a signal in accordance with aspects of the present invention.

As shown in the figure, magnetic loop antenna **2302** is arranged to receive signals **2402**. Changes in signals **2402** generate changes in a current **2404**, which is provided to a receiver **2406**.

Signals **2402** are electromagnetic waves. The interaction of signals **2402** induces magnetic fields within the magnetic material of the magnetic core of magnetic loop antenna **2302**. The magnetic fields within the magnetic core of magnetic loop antenna **2302** induce a current in an electrical excitation component of magnetic loop antenna **2302**. As the electromagnetic fields change within signals **2402**, the magnitude and/or polarity of the magnetic fields within the magnetic core of magnetic loop antenna **2302** similarly change. This change in the magnetic fields corresponds to current **2404**. Receiver **2406** is able to receive current **2404**, and changes therein, to decode signals **2402**. In this manner, magnetic loop antenna **2302** is a passive device, receiving a signal.

FIG. **25** illustrates a schematic view of an example magnetic loop antenna communication system **2500** in accordance with aspects of the present invention, wherein a magnetic loop is traveling in a clockwise direction.

As shown in the figure, system **2500** includes a core component **2502**, a transmitter/receiver **2504**, current line **2506**, current line **2508**, current line **2510**, current line **2512**, electrical excitation component **2514**, electrical excitation component **2516**, electrical excitation component **2518**, electrical excitation component **2520** and ground **2521**.

Transmitter/receiver **250** is arranged such that, in the transmission mode: a current **2522** is provided through current line **2506** to electrical excitation component **2514** and to ground **2521**; a current **2524** is provided through current line **2508** to electrical excitation component **2516** and to ground **2521**; a current **2526** is provided through current line **2510** to electrical excitation component **2518** and to ground **2521**; and a current **2528** is provided through current line **2512** to electrical excitation component **2520** and to ground **2521**.

Concentric magnetic field loops **2530** form around electrical excitation component **2514** as a result of current **2522**. Concentric magnetic field loops **2532** form around electrical excitation component **2516** as a result of current **2524**. Concentric magnetic field loops **2534** form around electrical excitation component **2518** as a result of current **2526**. Concentric magnetic field loops **2536** form around electrical excitation component **2520** as a result of current **2528**. Here, the dots of the concentric magnetic loops represent the magnetic field lines coming out of the paper, whereas the circles of the loops represent the magnetic field lines going into the paper.

Concentric magnetic field loops **2530**, **2532**, **2534** and **2536** couple into core component **2502**, forming magnetic field loop **2538** would have a clockwise polarity as represented by arrow **2540**.

FIG. **26** illustrates a schematic view of example magnetic loop antenna communication system **2500**, wherein a magnetic loop is traveling in a counter-clockwise direction.

Transmitter/receiver **2504** is arranged such that, in the transmission mode: a current **2622** is provided through current line **2506** to electrical excitation component **2514** and to ground **2521**; a current **2624** is provided through current line **2508** to electrical excitation component **2516** and to ground **2521**; a current **2626** is provided through current line **2510** to electrical excitation component **2518** and to ground **2521**; and a current **2628** is provided through current line **2512** to electrical excitation component **2520** and to ground **2521**.

Concentric magnetic field loops **2630** form around electrical excitation component **2514** as a result of current **2622**. Concentric magnetic field loops **2632** form around electrical excitation component **2516** as a result of current **2624**. Concentric magnetic field loops **2634** form around electrical excitation component **2518** as a result of current **2626**. Concentric magnetic field loops **2636** form around electrical excitation component **2520** as a result of current **2628**. Here, the dots of the concentric magnetic loops represent the magnetic field lines coming out of the paper, whereas the circles of the loops represent the magnetic field lines going into the paper.

Concentric magnetic field loops **2630**, **2632**, **2634** and **2636** couple into core component **2502**, forming magnetic field loop **2638** would have a counter-clockwise polarity as represented by arrow **2640**.

The gain of a magnetic loop antenna may be maximized by utilizing anisotropic magnetic materials. Magnetic anisotropy is the directional dependence of a material's magnetic properties. In the absence of an applied magnetic field, a magnetically isotropic material has no preferential direction for its magnetic moment, while a magnetically anisotropic material will align its moment with one of the easy axes. An easy axis is an energetically favorable direction of spontaneous magnetization that is determined by the known sources of magnetic anisotropy. The two opposite directions along an easy axis are usually equivalent, and the actual direction of magnetization can be along either of them.

A magnetic material with triaxial anisotropy still has a single easy axis, but it also has a hard axis (direction of maximum energy) and an intermediate axis (direction associated with a saddle point in the energy). An example embodiment exploits the hard axis of a triaxially anisotropic material. This will be described with reference to FIG. **27**.

FIG. **27** illustrates another example roll **2702** of an anisotropic magnetic film to be cut to form a core component in accordance with aspects of the present invention.

As shown in the figure, the anisotropic magnetic film of roll **2702** has an easy axis along the direction indicated by double arrow **2704** and a hard axis in the direction indicated by arrow **2706**.

The first step in using magnetic film materials is to identify their axes of anisotropy. In this example, a magnetic film is sputtered so as to exhibit a hard axis that is parallel to the direction of roll processing. Once the anisotropy axes have been identified, roll **2702** is cut in a manner similar to that discussed above with reference to FIG. **18**. However, in this instance roll **2702** is cut parallel to the hard axis.

Roll **2702** is then cut into widths equal to the vertical height desired for a predetermined magnetic loop antenna. In an example embodiment, a roll is cut into strips that are 0.25" wide to make a 0.25" high magnetic loop antenna.

By taking advantage of the hard axes, a magnetic loop core component in accordance with aspects of the present invention is able to couple a much larger amount of the magnetic field lines from an electrical excitation component.

A magnetic loop antenna in accordance with aspects of the present invention may provide a similar transmission function to that of the conventional electric monopole antenna. This will be described in greater detail with reference to FIGS. **28-29**.

FIG. **28** is a graph **2800** illustrating gain as a function of two angles for an example conventional monopole antenna.

As shown in the figure, graph **2800** includes a y-axis **2802** measuring an angle in degrees, and an x-axis **2804** measuring an angle in degrees and scale **2806** measuring gain in dB.

Scale **2806** indicates that gain for graph **2800** ranges from about −14 dB to about 6 dB. An area **2814** of graph **2800** around 45° has the largest gain, at about 3 dB. Area **2814** is bounded by a sudden drop to approximately a 0 gain at approximately 30° and 75°. The lowest gains are registered at 0° and 180°. A lobeing effect is shown at **2816** and **2818**, as a result of signal dispersion from a square mounting plane.

FIG. **29** illustrates is a graph **2900** illustrating gain as a function of two angles for an example magnetic loop antenna in accordance with aspects of the present invention.

As shown in the figure, graph **2900** includes a y-axis **2902** measuring an angle in degrees, and an x-axis **2904** measuring an angle in degrees and scale **2906** measuring gain in dB.

The similarities between graph **2800** of FIG. **28** and graph **2900** of FIG. **29** highlight the similar transmission functions of a conventional dipole antenna and a magnetic loop antenna in accordance with aspects of the present invention. Similar to scale **2806** of FIG. **28**, scale **2906** indicates that gain for graph **2900** ranges from about −14 dB to about 6 dB. Similar to area **2814** of FIG. **700**, an area **2914** of graph **2900** around 45° has the largest gain, at about 3 dB. Similar to area **2814** of FIG. **700**, area **2914** is bounded by a sudden drop to approximately a 0 gain at approximately 30° and 75°. Similar to graph **2800**, in graph **2900**, the lowest gains are registered at 0° and 180°. Graph **2900** has slightly less lobeing effects than graph **2800**, as shown at **2916** and **2918**.

In accordance with aspects of the present invention, a magnetic core component is made of a wound magnetic film, wherein the magnetic film includes a magnetic material layer and a substrate. In the non-limiting examples discussed above, the magnetic core component has a circular shape. It should be noted that a magnetic core component in accordance with aspects of the present invention may have a non-circular shape, non-limiting examples of which include oval and elliptical. Further, if a mandrel is used to wind a core component in accordance with aspects of the present invention, the mandrel may have any shape that is conducive to winding, non-limiting examples of which include star-shaped and polygonally shaped.

The foregoing description of various preferred embodiments of the invention have been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed, and obviously many modifications and variations are possible in light of the above teaching. The exemplary embodiments, as described above, were chosen and described in order to best explain the principles of the invention and its practical application to thereby enable others skilled in the art to best utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the claims appended hereto.

What is claimed as new and desired to be protected by Letters Patent of the United States is:

1. An antenna comprising:

an electrical excitation component having an input, an output and a conducting component, said conducting component being disposed between said input and said output and being operable to conduct current from said input to said output; and

a core component comprising a wound magnetic film having a substrate and a magnetic material layer, said core component being operable to have a magnetic current loop induced therein,

wherein said electrical excitation component is arranged such that concentric magnetic fields associated with current conducted through said electrical excitation component are additionally associated with a magnetic current loop within said core component.

2. The antenna of claim **1**,

wherein said substrate has a substrate thickness,

wherein said magnetic material layer has a magnetic material layer thickness, and

wherein the magnetic material layer thickness is larger than the substrate thickness.

3. The antenna of claim **1**,

wherein said magnetic film has a magnetic film thickness, a magnetic film width and a magnetic film length,

wherein the magnetic film thickness is less than the magnetic film width, and

wherein the magnetic film width is less than the magnetic film length.

4. The antenna of claim **3**,

wherein said magnetic material layer comprises an anisotropic magnetic material having an easy axis and a hard axis, and

wherein the hard axis is parallel with the magnetic film length.

5. The antenna of claim **1**, wherein said magnetic material layer comprises one of the group consisting of NiZn ferrite, Co_2Z hexaferrite, CoFeSiNoB ferromagnetic metal alloy, CoZrNb ferromagnetic metal alloy, and combinations thereof.

6. A method of making an antenna, said method comprising:

providing a mandrel;

anchoring an end of a magnetic film to the mandrel, the magnetic film having a substrate and a magnetic material layer;

winding the magnetic film around the mandrel so as to create a core component surrounding the mandrel, the core component being operable to have a magnetic current loop induced therein; and

arranging an electrical excitation component with the core component such that concentric magnetic fields associated with current conducted through the electrical excitation component are additionally associated with the magnetic current loop within the core component.

7. The method of claim **6**,

wherein the magnetic film has a substrate that has a substrate thickness,

wherein the magnetic material layer has a magnetic material layer thickness, and

wherein the magnetic material layer thickness is larger than said substrate thickness.

8. The method of claim **6**,

wherein the magnetic film has a magnetic film thickness, a magnetic film width and a magnetic film length,

wherein the magnetic film thickness is less than the magnetic film width, and

wherein the magnetic film width is less than the magnetic film length.

9. The method of claim **8**,

wherein the magnetic material layer comprises an anisotropic magnetic material having an easy axis and a hard axis, and

wherein the hard axis is parallel with the magnetic film length.

10. The method of claim **6**, wherein the magnetic material layer comprises one of the group consisting of NiZn ferrite, Co_2Z hexaferrite, CoFeSiNoB ferromagnetic metal alloy, CoZrNb ferromagnetic metal alloy, and combinations thereof.

11. The method of claim **6**, further comprising:

unwinding the magnetic film from a roll of magnetic film; and

managing the tension of the magnetic film via a tension management device.

12. The method of claim **11**, wherein said managing the tension of the magnetic film comprises managing the tension of the magnetic film via a roller operable to rotate about an axis.

13. The method of claim **12**, further comprising moving the roller in a direction to adjust the tension of the magnetic film.

14. The antenna of claim **1**, further comprising to transmitter operable to provide the current to said electrical excitation component.

15. The antenna of claim 1, further comprising a receiver operable to receive the current from said electrical excitation component.

16. The antenna of claim 1, further comprising:

a second electrical excitation component having a second input, a second output and a second conducting component,

wherein said second conducting component is disposed between said second input and said second output and is operable to conduct a second current from said second input to said second output, and

wherein said second electrical excitation component is arranged such that second concentric magnetic fields associated with the second current conducted through said second electrical excitation component are additionally associated with the magnetic current loop within said core component.

17. The antenna of claim 16, wherein the second current is different from the current.

18. The antenna of claim 1,

wherein said magnetic film has a magnetic film thickness, a magnetic film width and a magnetic film length,

wherein the magnetic film thickness is less than the magnetic film width,

wherein the magnetic film width is less than the magnetic film length,

wherein said magnetic material layer comprises an anisotropic magnetic material having an easy axis and a hard axis,

wherein the hard axis is parallel with the magnetic film length, and

wherein said magnetic material layer comprises one of the group consisting of NiZn ferrite, Co_2Z hexaferrite, CoFeSiNoR ferromagnetic metal alloy, CoZrNb ferromagnetic metal alloy, and combinations thereof.

19. The antenna of claim 8, further comprising:

a second electrical excitation component having a second input, a second output and a second conducting component,

wherein said second conducting component is disposed between said second input and said second output and is operable to conduct a second current from said second input to said second output, and

wherein said second electrical excitation component is arranged such that second concentric magnetic fields associated with the second current conducted through said second electrical excitation component are additionally associated with the magnetic current loop within said core component.

20. The antenna of claim 19, wherein the second current is different from the current.

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